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Anti-drought measures and their effectiveness: A study of farmers' actions and government support in China

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ABSTRACT

In China, the principal actors that are involved in combating drought in agricultural production are farmer households and the government. Prevailing research rarely focuses on both actors. At the same time, the effectiveness of anti-drought measures has been largely evaluated through farmers' anti-drought initiatives. But it is unclear from this literature if such initiatives result in better economic livelihoods. This paper will examine: (i) indicators of government and farmer activities that impact the latter's anti-drought actions, and (ii) the effect of anti-drought actions on farmers' agricultural income. Based on over 1000 household surveys conducted at major grain production areas in the North China Plain, two findings emerge. First, farmers' participation in local village organizations, government financial assistance, local government institutional support, and disaster warnings through multiple media channels positively influence farmers' anti-drought actions. Second, the combined efforts of both farmers and government in mitigating drought as well as labor, factors of production and social capital (local cooperative membership, phone contacts) are significant determinants of agricultural income. This study contributes to the ecological indicators literature by assessing the effectiveness of anti-drought metrics.

1. Introduction

In the context of agricultural ecosystems, drought is increasingly recognized to be an invisible hazardous event that is associated with below-average precipitation for a protracted period. Shortage of water causes stress on agricultural systems that negatively affects plant life. Moisture availability is severely curtailed; in turn, this impairs plant growth leading to lower agricultural yields. Drought is therefore not just a physical but also a socio-economic event that impacts societies through its potential threat on grain security (Misselhorn, 2005; Sivakumar and Motha, 2007; Ye et al., 2013). The occurrence, degree and frequency of different levels of droughts have been on the rise as the effect of climate change becomes apparent (Dai, 2011; IPCC, 2007). According to IPCC's estimates, occurrence of extreme weather events will exert a significant influence on agricultural production and human lives in many countries. The area that is affected by drought worldwide is expected to expand by 15%–44% from the current level by the end of this century. One billion people in Asia may be threatened by drought and drought-induced grain crisis by 2050 (Cruz et al., 2007). In China, the crop area affected by drought has increased from 8% to 16% while the disaster area (which denotes the area experiencing more than 30% fall in grain yield) has increased by nearly 20% over the last 70 years (NBSC, 2015). In 2000, grain yield reduction attributed to drought accounted for 13% of the total grain yield of the year, incurring enormous economic losses (MWRC, 2010). Since climate change is difficult to reverse, mitigating the negative effects of drought through use of appropriate measures is a central question confronting society and policy-makers (IPCC, 2007; UNDP, 2015; Wei et al., 2011).

As rational actors in agricultural production, farmer households commonly adopt anti-drought measures by adjusting crop planting structure, production factor input and intensity of irrigation based on their perception of drought and agricultural production experiences (Deressa et al., 2009; Hisali et al., 2011; Rajiv et al., 2018). Many studies have paid close attention to the actions that farmer households undertake to combat drought and the factors that influence their actions (Bryan et al., 2013; Jalón et al., 2016; Jin et al., 2016a; Liu and Wang, 2012; Porter et al., 2014; Sun et al., 2013; Yang et al., 2015). They show that farmers' perception of drought and their personal risk preference are key factors that determine whether they will undertake anti-drought measures or not (Carlton et al., 2016; Deressa et al., 2011). Other studies evaluate the effects of farmer households' measures, and found that certain appropriate measures can reduce the negative

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impacts of drought on agricultural production (Falco et al., 2011; Holden and Shiferaw, 2004; Xiao and Tao, 2014). For instance, IPCC (2012) argues that when temperature rises, planting alternative varieties of crops or adopting other field management methods can help to reduce drought-induced losses by 10% to 15%. If proper measures are undertaken, agricultural production can even benefit from global warming (Tian et al., 2014; Xiong et al., 2005).

Farmers' voluntary self-help actions can generate some negative effects. For example, excessive use of fertilizers and pesticides can result in hardened and impervious soil, and a decline in the quality of crops (Ju et al., 2016). Scientific guidance from the government may be necessary to alleviate such negative effects (Paavola, 2008). Farmers may be unaware of the risks of overuse of fertilizers and respond negatively. Without government's influence, farmer households may not be able to weather frequently occurring droughts only with spontaneous anti-drought behavior. The government must intervene by encouraging farmers to fight against drought in a scientific way, improving farmers' field management measures, stabilizing and even enhancing their living standard (Hisali et al., 2011; Keshavarz and Karami, 2014). Cater and his colleagues found that government support such as improving infrastructure can help to prevent farmer households from falling into a vicious circle of poverty due to economic damages from disasters (Carter et al., 2007). International organizations like the World Bank and IPCC have called on policy-makers of countries to incorporate climate change adaptation into their national development plan systems (IPCC, 2007, 2012; World Bank, 2010). China's response to this has been to issue the Drought Control Regulation of the People's Republic of China in 2009. These are guidelines that target drought measures but they also outline the provision of pre-warning information and government subsidies.

While both farmers and governments in China are taking active measures to combat drought, it is still unclear what measures or indicators are effective. Who should be the principal actor in fighting future droughts in the domain of agricultural production in China, farmer households or the government? Currently, there are not many studies that examine the above questions. Although there are studies that examine the effect of government's supporting measures, they are interested in the extent to which policy factors have succeeded in promoting farmers' initiative in fighting drought as their evaluation criterion (Chen et al., 2014; Falco et al., 2011; Wang et al., 2014, 2015). The ultimate objective of undertaking anti-drought measures is to reduce agricultural loss and to stabilize or even improve agricultural production and income. Using farmers' initiatives as the core criterion to evaluate the effectiveness of the government's support merely captures the intermediate process of effectiveness assessment while ignoring wider socio-economic impact on farmers and their income. Examining the factors that explain the drought-livelihood relationship in Iran for example, Khayyati and Aazami (2016) showed that drought duration has a more adverse effect on livelihood than drought severity. Instead of focusing on the nature of drought on livelihood and income as Khayyati and Aazami, this paper will attempt to examine the following. First, it seeks to explain the indicators that characterize farmers' initiatives on drought. Second, it analyzes if farmers' actions, government anti-drought efforts, or the actions of both actors favorably influence livelihood and agricultural income. Investigating the aforementioned two questions should enhance our understanding of the metrics of anti-drought behavior's effectiveness.

2. Research design and methodology

2.1. Study area

North China Plain is the second largest plain in China. It is located on the lower reach of the Yellow River (Fig. 1) with an altitude that is below 50 m. Most parts of this area have a warm temperate monsoon climate with four clearly distinct seasons. The main vegetation type is temperate deciduous broad-leaved forest. Due to its flat topography, deep soil and relatively abundant sunshine, the plain is highly suitable for farming and has a long history in agricultural development. The total area is about 30 million hectares, while the arable land area is 24.4 million hectares, among which paddy fields, irrigated land and arid land make up 3%, 54% and 43% respectively (Yang et al., 2010). As a major producing region for agricultural products like wheat, corn, apples, etc., its average annual grain yield accounts for 30% of the national total. North China Plain occupies a prominent position in China's agricultural sector (Yin et al., 2015).

However, frequent droughts caused by the lack of rainfall as well as the uneven distribution of precipitation throughout the year or bi-annually are becoming the most important constraint for crop cultivation. The average precipitation is under 600 mm, and 80% of the rain occurs between June and September. Spring and Summer droughts are the most severe, and three-year drought is a common occurrence (Lu et al., 2010). In the context of climate change, acidification of the agricultural ecosystem is becoming more and more obvious (Tan et al., 2010). According to some studies, the frequency of drought in the North China Plain was as high as 46.8% during the period of 1960–2009. The average area affected by drought was up to 28% of the national total (Lu et al., 2010). From 1951–1966, drought resulted in 1022.1 thousand tons reduction in the area's average annual grain output, and this decline reached 5930 thousand tons between 1988 and 2010 (Hu et al., 2013). In recent years, the temperature has continued to rise while precipitation has seen a downward trend in the area. This in turn has exacerbated the acidification process (Zou et al., 2010; Zhang et al., 2011) and increased tension between drought and agricultural production (Ma and Fu, 2006). Given the context described here, the area's representation of drought and agricultural production in China is reasonable and of practical significance.

2.2. Data and survey

Data are mainly drawn from field questionnaire surveys conducted in three provinces of the North China Plain (Hebei, Henan and Shandong provinces). The surveys were supplemented by government reports and statistical yearbooks. Household sampling used random sampling and proportional sampling. The final sample size was 5% of total farmer households in the three regions. The survey was conducted on-site with field staff interviewing individual households.[1] While this was time-consuming and costly, problems arising from relatively low literacy level as well as reporting bias are minimized in this manner. To ensure that farmers were providing relatively accurate information on government support as well as the government's role on disaster resistance, a second set of questionnaires was designed that were aimed at government officials. As we point out below, this allowed us to cross-check against farmer's reporting bias. But the geographical level at which official supports or disaster warnings is being realized also occurs at three scales, namely county, township and village levels. Hence, the second set of questionnaires covered all three geographical scale levels using random sampling and stratified sampling (county: town: village = 1:3:9).

We began by having a roundtable discussion with officials from the Provincial Agriculture Department to understand the general patterns of agricultural production and disasters happening in the province. From the Department, a list of all drought-affected counties was obtained and sampled. We then surveyed and interviewed core county-level governmental agencies for example the Weather Bureau and Agricultural Bureau to get more details about the county. From the officials, a list of all drought-affected towns was solicited and provided to us. The county-level questionnaire contained 60 indicators that were

[1] Government-sponsored research in China does not require approval from the ethics commission.